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TECHNICOLOR MECHANISMS FOR SINGLE TOP PRODUCTION

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We investigate the contribution of technicolor mechanisms to the production of single top quarks at hadron colliders. We find that a promising candidate process is gluon-gluon fusion to produce a W-boson plus technipion, with subsequent decay of the technipion to a top quark plus a bottom quark. The top-plus-bottom mode is the dominant one when the technipion mass is larger than the top mass. We calculate the total cross section and the p_T distribution for the technipion production at Tevatron and LHC energies for a range of technipion masses, starting at 200 GeV. The decay chain of technipion to top plus bottom quarks and then top to W plus bottom yields a final state with two W's and two bottom quarks. We study the backgrounds to our process and the kinematic cuts that maximize the signal to background. We report event rate estimates for the upgraded Tevatron and the LHC.

The discovery of the top quark [1] has opened up an exciting area of physics. Top production by non Standard Model (SM) mechanisms are of great value in probing new physics. It has been known for some time that the SM is not completely satisfying. It does not explain electroweak symmetry breaking and has many free parameters. Technicolor (TC) has emerged as one of the possible successors to the SM, and we present results of single top production by TC here. We know the low-energy region of QCD can be represented by a nonlinear sigma-type model [2]. Thus we invoke a low-energy effective Langrangian for a class of technicolor theories which is motivated by the chiral symmetry of the Technicolor Lagrangian and the observation of vector-meson dominance in QCD [2]. We are interested in the production of single top quarks and we look at the gluon fusion process $gg \rightarrow W + P_8$ where P_8 indicates a color octet, SU(2) doublet technipion [3]. The technipion predominantly decays to a top quark and a bottom quark, assuming $M_{P_8} > m_t$ [4]. The lowest order processes contributing to this gluon fusion are: the $ggWP_8$ 4-point interaction diagram, the s-channel gluon exchange diagram, and the 2 diagrams with P_8 exchange in the t and u channels.

Table 1: p_T distribution

p_T (TeV)	0.1	0.2	0.4	0.6	0.8	1.0
$\frac{d\sigma_{TC}}{dydp_T}$ (fb TeV^{-1})	62.0	46.6	14.4	4.3	1.4	0.5

Table 2: Technipion cross sections and events per year

	M_{P_8} = 240 GeV	300 GeV	350 GeV	400 GeV
σ_{TC}				
$\sqrt{s}$ = 2 TeV	0.059 fb	0.016 fb	0.0059 fb	0.0022 fb
$\sqrt{s}$ =14 TeV	56 fb	31 fb	20 fb	14 fb
# events per year				
$\sqrt{s}$ = 2 TeV	0.37	0.10	0.04	0.01
$\sqrt{s}$ = 14 TeV	1.7×10^4	9.7×10^3	6.3×10^3	4.4×10^3

In the Farhi-Susskind type model that we use for the present analysis, the vertices needed are the single pseudoscalar effective Lagrangian $\mathcal{L}(\phi)_{eff} = \frac{iN_{TC}}{16\pi^2 F_T}\epsilon^{\mu\nu\lambda\rho}\int dx(\partial_\mu G^b_\nu + \frac{1}{2}g_3 f^{bcd}G^c_\mu G^d_\nu)g_2 g_3(P_8^{+,b}\partial_\lambda W^-_\rho + P_8^{-,b}\partial_\lambda W^+_\rho)$, the normal parity P_8-P_8-G effective interaction Lagrangian [5] and the usual QCD triple gluon vertex. Using these vertices and the tree-level diagrams described above, we computed the order $\alpha_2^2\alpha_3$ p_T distributions and the total cross section for technipion production at Tevatron and LHC energies. The final state that results from the $P_8 + W$ production and subsequent decay of P_8 into $t + b$ and then t into $W + b$ is the same $WWbb$ final state that results from $t + \bar{t}$ production and decay. We comment below on cuts that reduce the $t + \bar{t}$ background. The p_T distribution for $p\overline{p} \to W + P_8$ has its peak at $p_T \simeq 0.1$ TeV for M_{P_8} = 240 GeV and $\sqrt{s}$=14 TeV. We show several $\frac{d\sigma}{dydp_T}$ values in the range between 0.1 TeV and 1 TeV for $y = 0$, M_{P_8} = 240 GeV, and $N_{TC} = 3$ in Table 1 in units of fb TeV^{-1}. In Table 2 we give the corresponding total cross sections for technipion production for a range of technipion masses. We also show the events per year expected with the upgraded Tevatron and with the LHC at luminosities of $2 \times 10^{32} cm^{-2}s^{-1}$ and $10^{34} cm^{-2}s^{-1}$, respectively. At Tevatron energies and expected luminosities, the event rate is unobservably small. At the LHC, however, the event rate is large enough to be interesting, allowing rather severe cuts to be made to reduce background and not lose the whole signal. For $\sqrt{s}$=14 TeV, and a top mass of 180 GeV, the single top cross section is 117 pb, while the $t\bar{t}$ cross section is 525 pb [6]. Monte Carlo studies

indicate that the $WWbb$ decay products of the TC signal differ from those of the SM $t\bar{t}$ production and decay in that the TC p_T spectrum of the recoil W is harder than the W spectrum of $t\bar{t}$ and the b and $\bar{b}$ are not back-to-back. For example if we impose a typical $p_T > 400$ GeV cut on W and a cos θ >0.6 on on the $b\bar{b}$ opening angle, the fraction of SM $t\bar{t}$ events passing these cuts is less than 10^{-3} while the fraction of TC events passing the cuts is about 5×10^{-2}. By tuning these cuts, one can substantially reduce the SM $t\bar{t}$ background in comparison to the TC signal. Thus our preliminary study indicates that a search for charged, colored technipions in the $WWbb$ final state at the LHC is feasible.

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